Observations and Mechanistic Models of Dengue in Singapore

Submitted under the title: A mechanistic model for dengue under the coexistence of Aedes aegypti and Aedes albopictus in endemic areas

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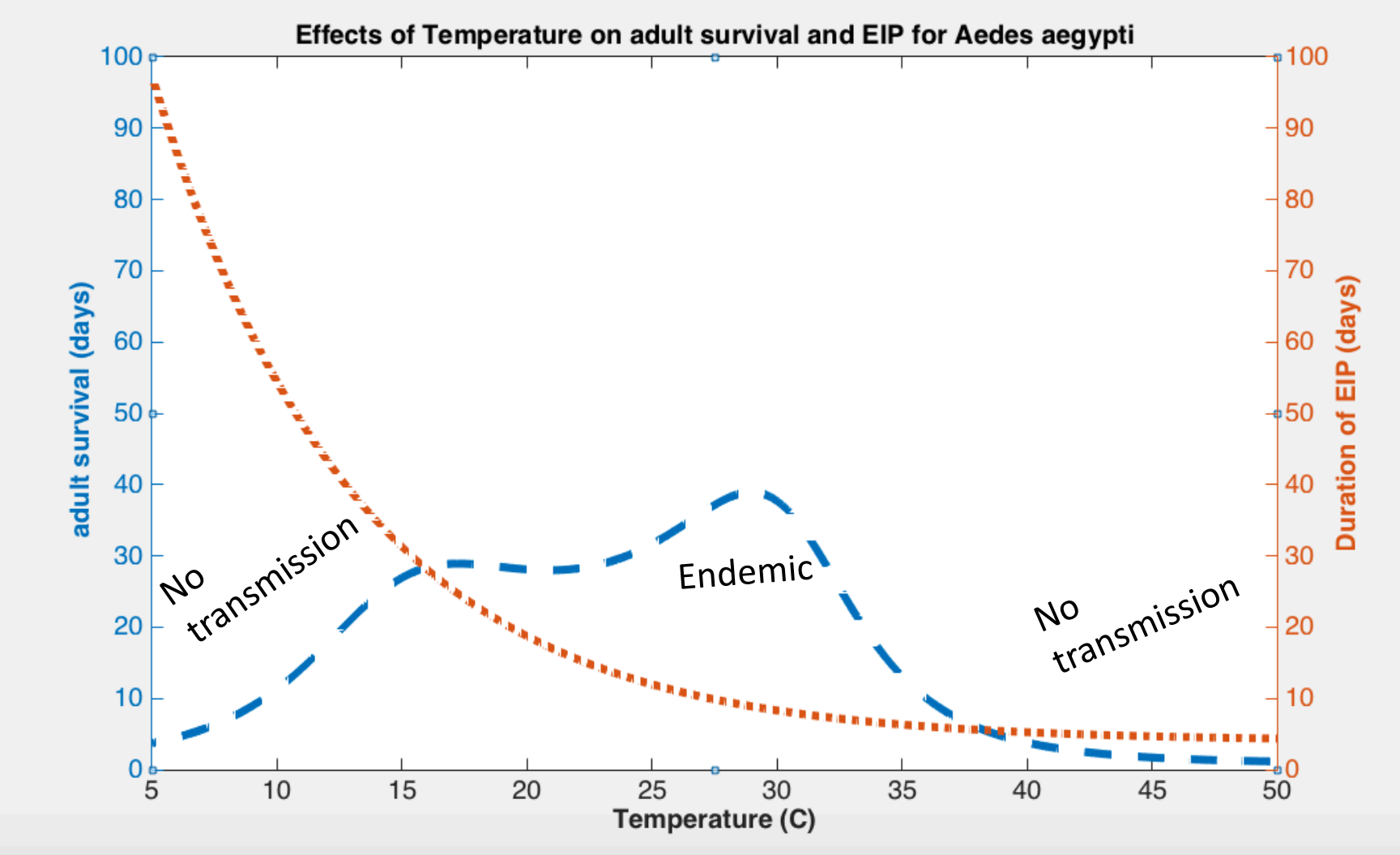
Where/when does dengue transmission occur?



How do we study dengue and climate?

1. Computational: Mechanistic Modeling (2011-2016)

2. Observational: Fieldwork in Singapore (2013-2015)

Singapore: Study area

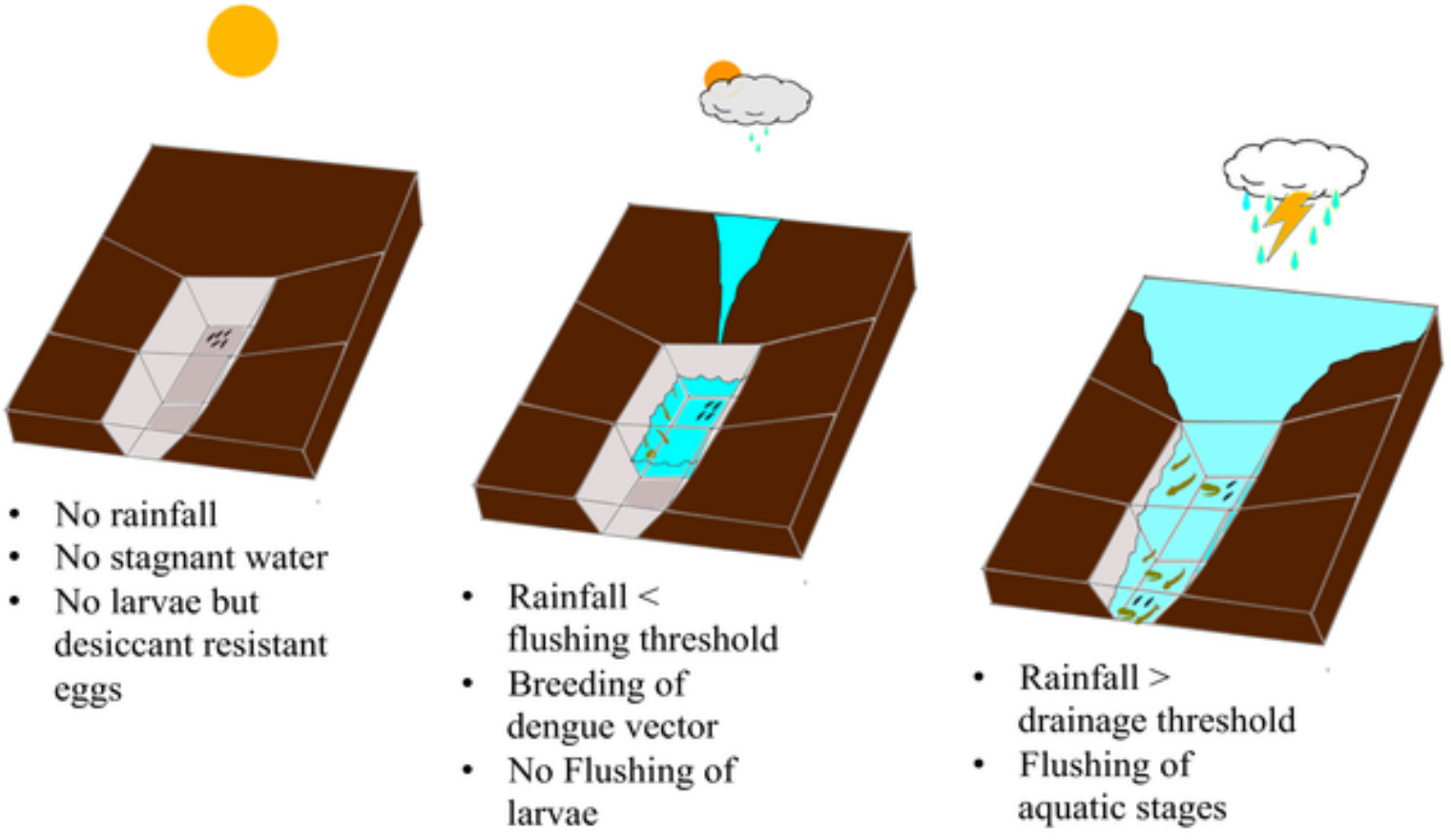
Two main findings from the field work 2013-2015

1. **A monsoonal sequence of flushing-drying in breeding drains of *Aedes aegypti* happens before seasonal decline in dengue.**

2. More dengue cases were reported from a low-rise subarea. This risk is influenced by outdoor breeding of *Ae. aegypti* in low-rise area.

Dengue and Rainfall in Singapore

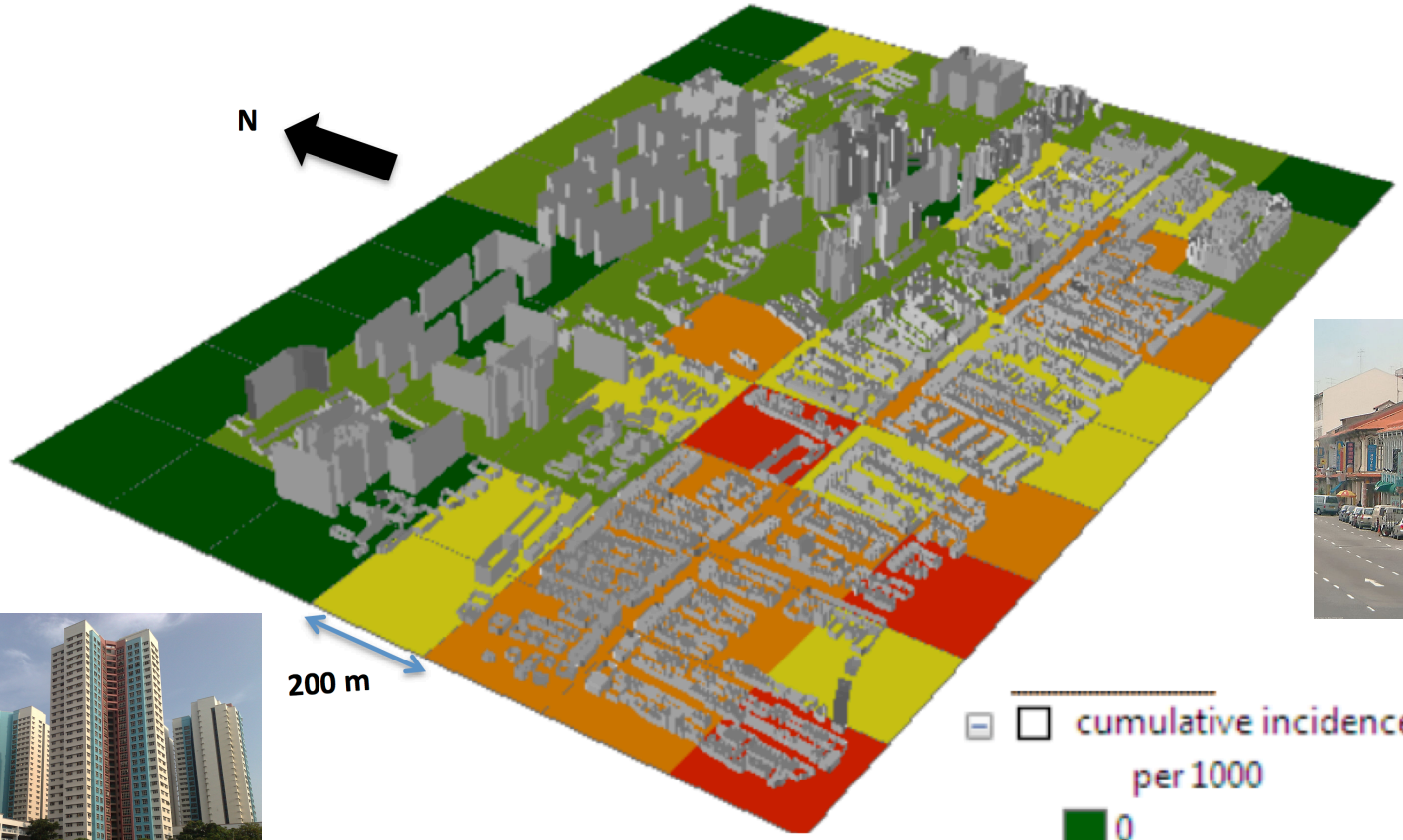
Fig 3. A descriptive sketch for the rainfall flushing mechanism shows how intense rainstorms during the monsoon results in washing breeding of dengue vector from stagnant drains.



Seidahmed OME, Eltahir EAB (2016) A Sequence of Flushing and Drying of Breeding Habitats of Aedes aegypti (L.) Prior to the Low Dengue Season in Singapore. PLoS Negl Trop Dis 10(7): e0004842. doi:10.1371/journal.pntd.0004842
http://journals.plos.org/plosntds/article?id=info:doi/10.1371/journal.pntd.0004842

PLOS | NEGLECTED TROPICAL DISEASES

Urban housing and risk of dengue

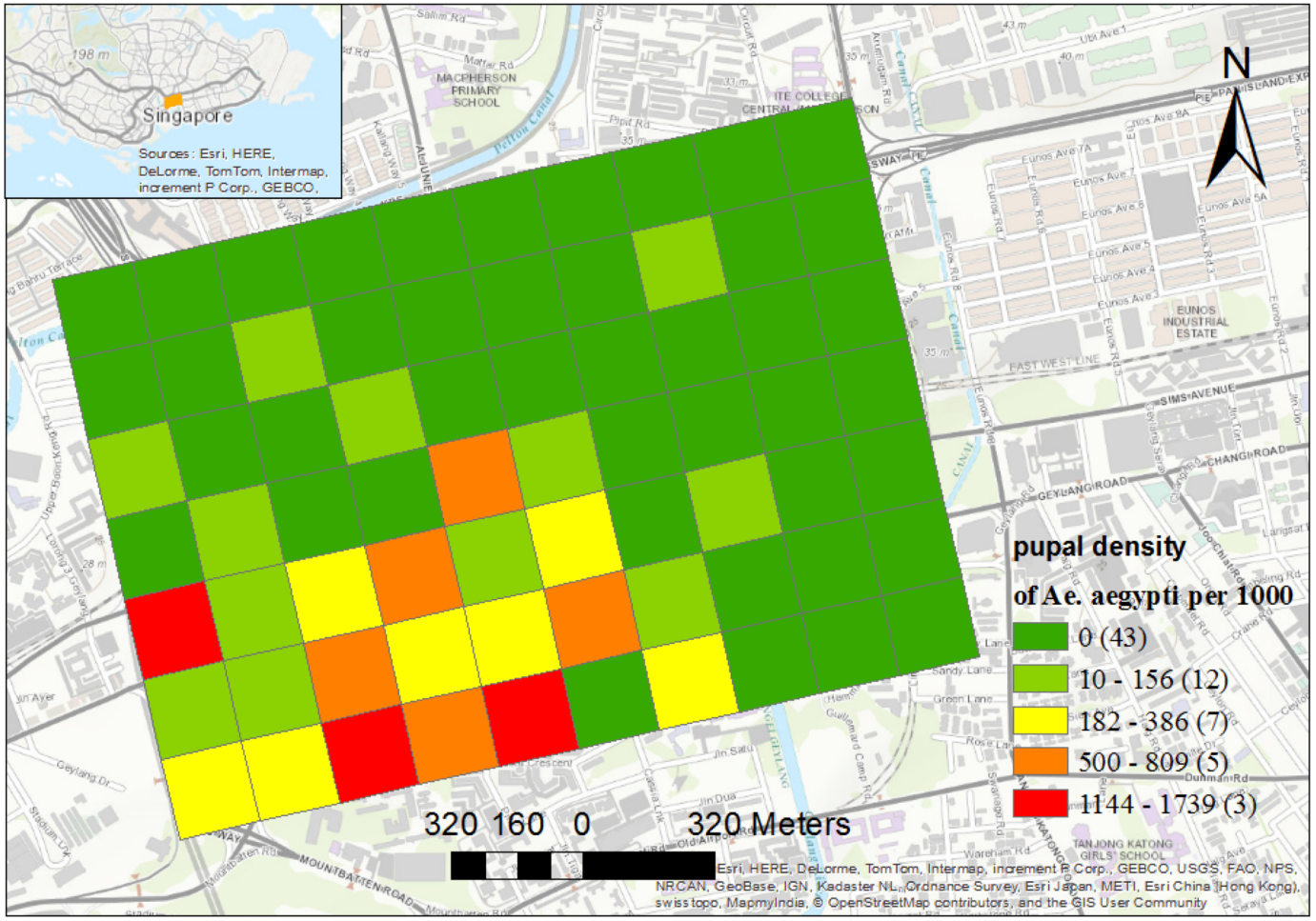


Low rise houses

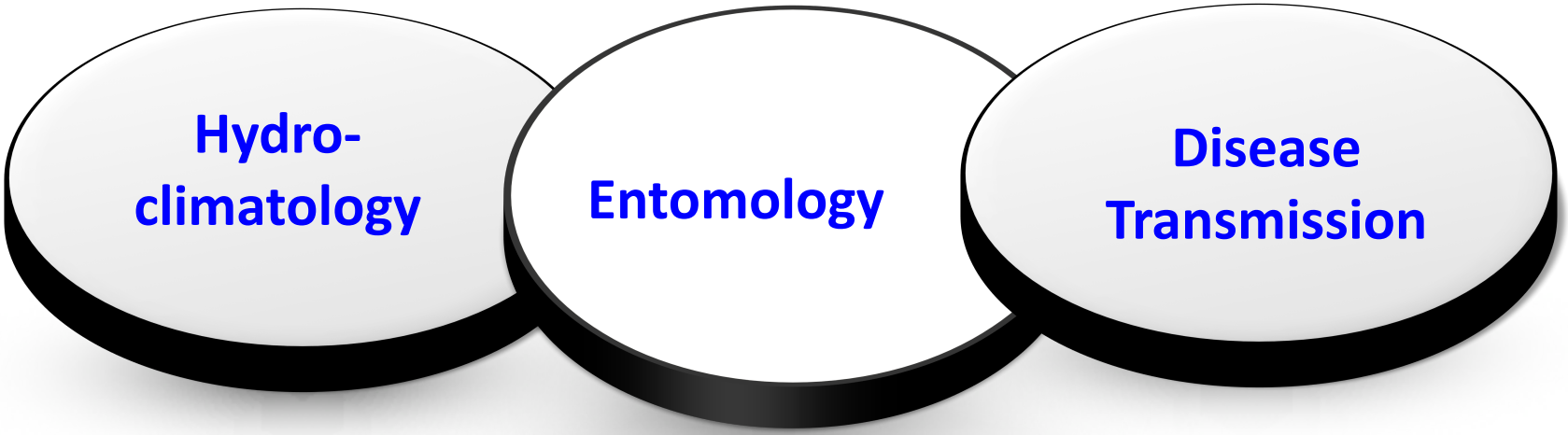
High rise houses

cumulative incidence (2010-2013)
per 1000
0
1 - 78
79 - 170
171 - 272
273 - 523
Buildings

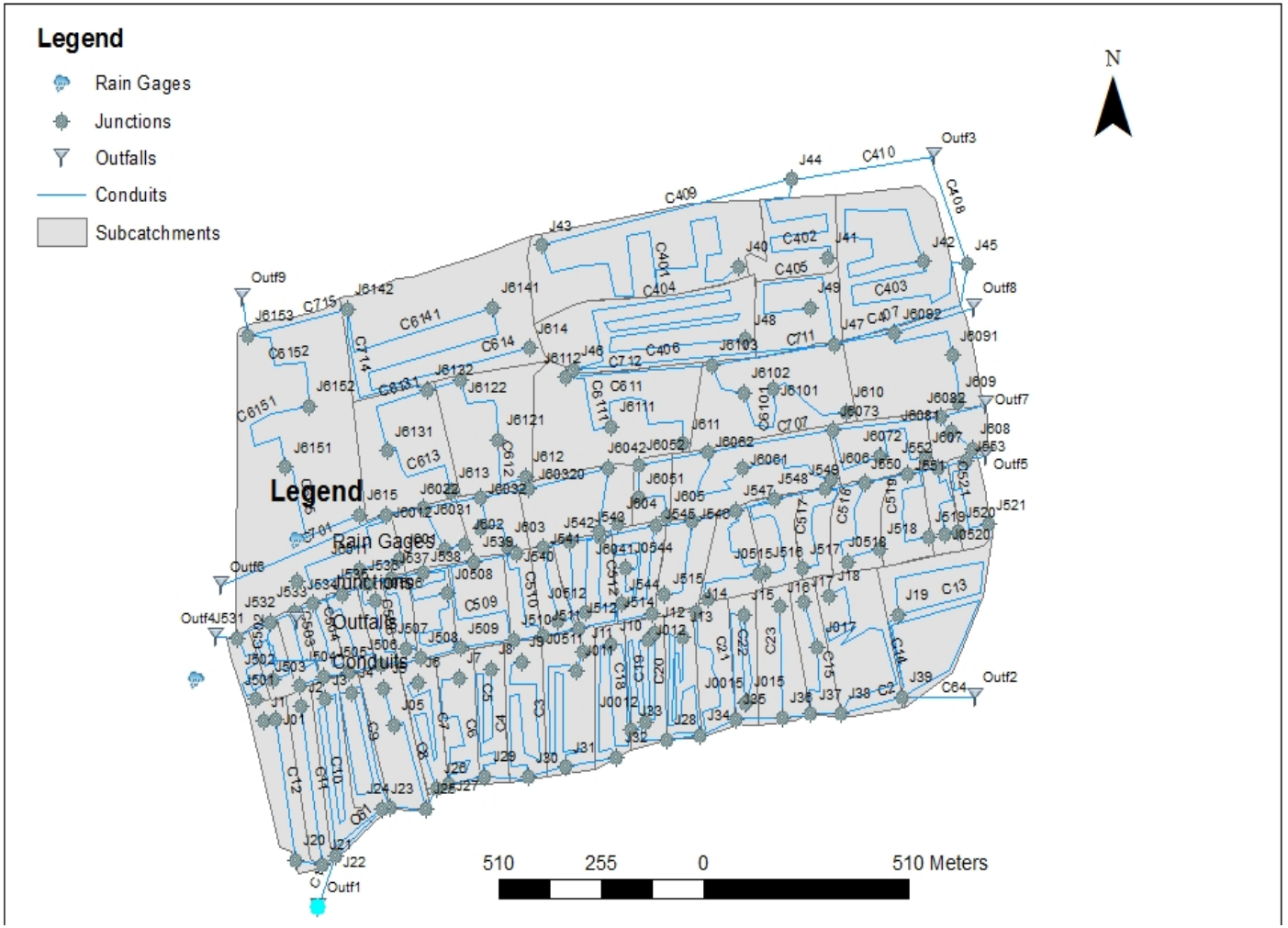
Outdoor abundance of Dengue vector



Mechanistic Modeling: Coupling Hydrology, Entomology and Dengue Transmission Simulator (HYDREDETS)

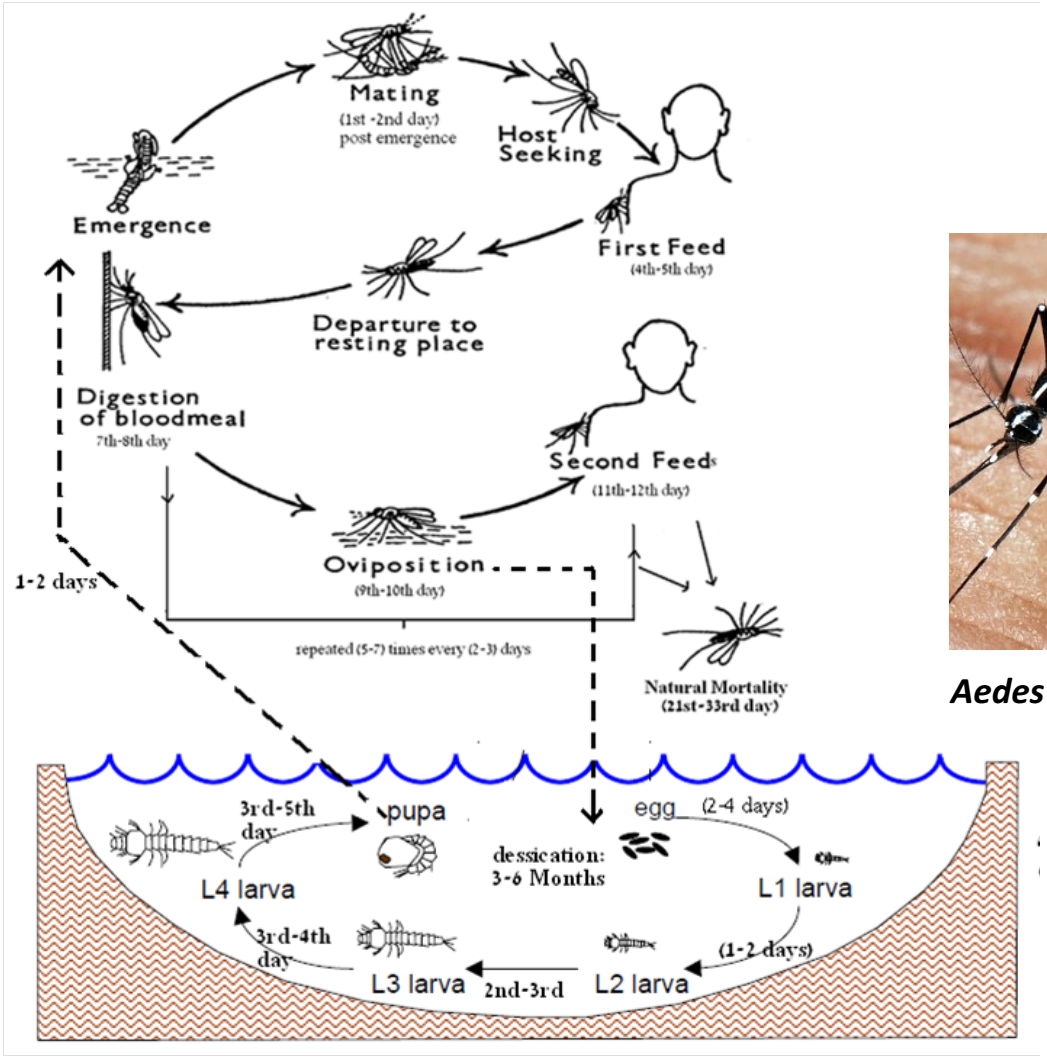


1) An explicit urban hydrology model



2) A mechanistic model for the lifecycles of *Aedes aegypti and Aedes albopictus*

Aedes aegypti (L.)



Aedes Albopictus (Skuse)

Inter/intra specific competition
Predation
Food availability

Rainfall effects on aquatic cohorts

Flushing of aquatic cohorts

$$n_t = \frac{N_t}{V_t}$$

$$n_{t+1} = \frac{n(t) \times V(t)}{V_{t+1}}$$

$$N_{t+1} = n_{t+1} \times V_t$$

N= total of aquatic stages, V= Water volume (m^3) , n= density of aquatic stages per volume, t= time step (hr)

One-dimensional displacement of flushed cohorts between grids

$$dd = v \times t$$

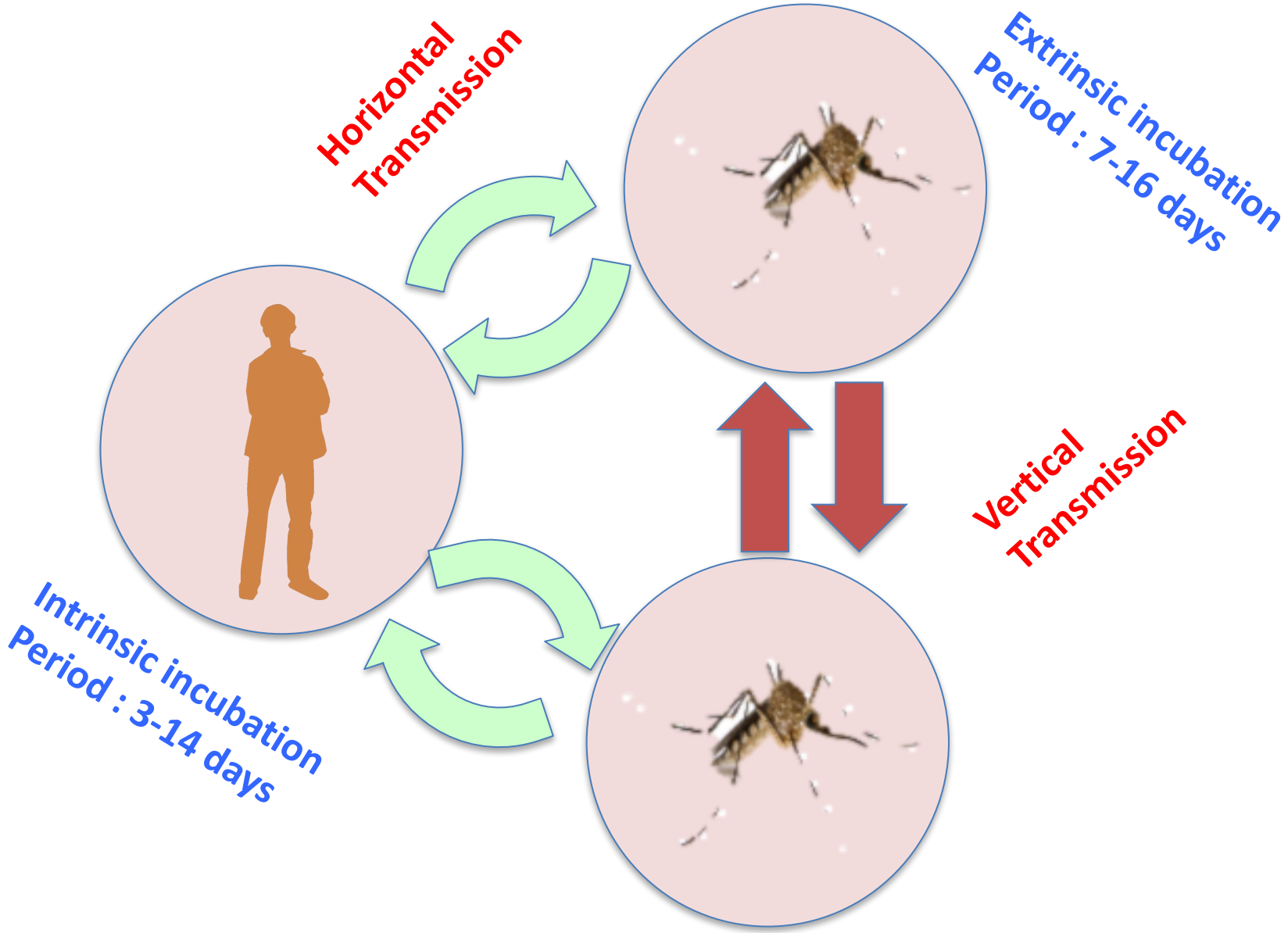
$$dd < dd_{mn} \rightarrow i = i$$

$$dd > dd_{mx} \rightarrow i = 0$$

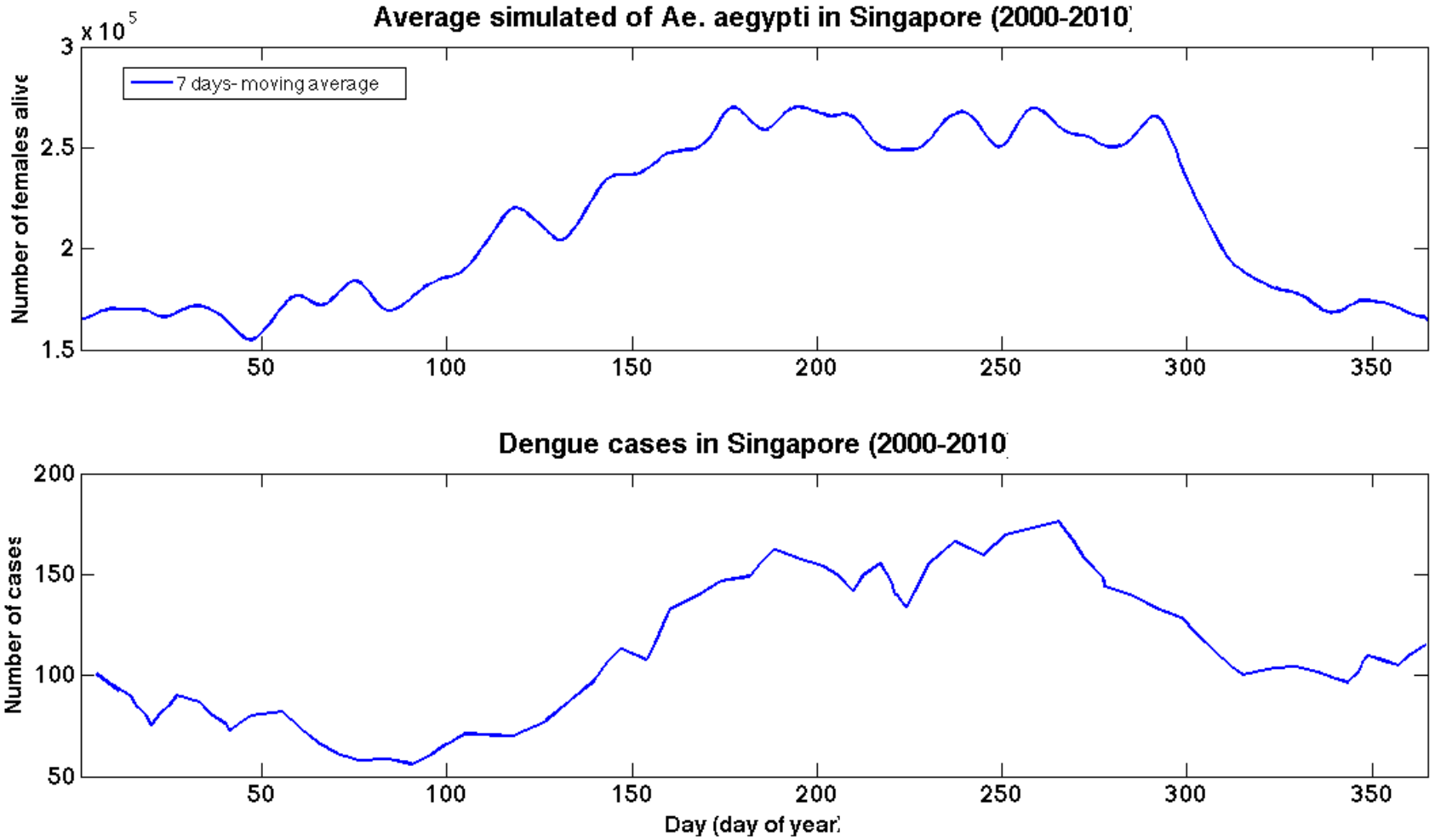
$$dd_{mn} < dd < dd_{mx} \rightarrow i = i + dd$$

dd= Displaced distance (m), v= Water Velocity (m/hr), dd_{mn}=minimum x dimension (m) , dd_{mx}= maximum x directions , i= x location of the cohort

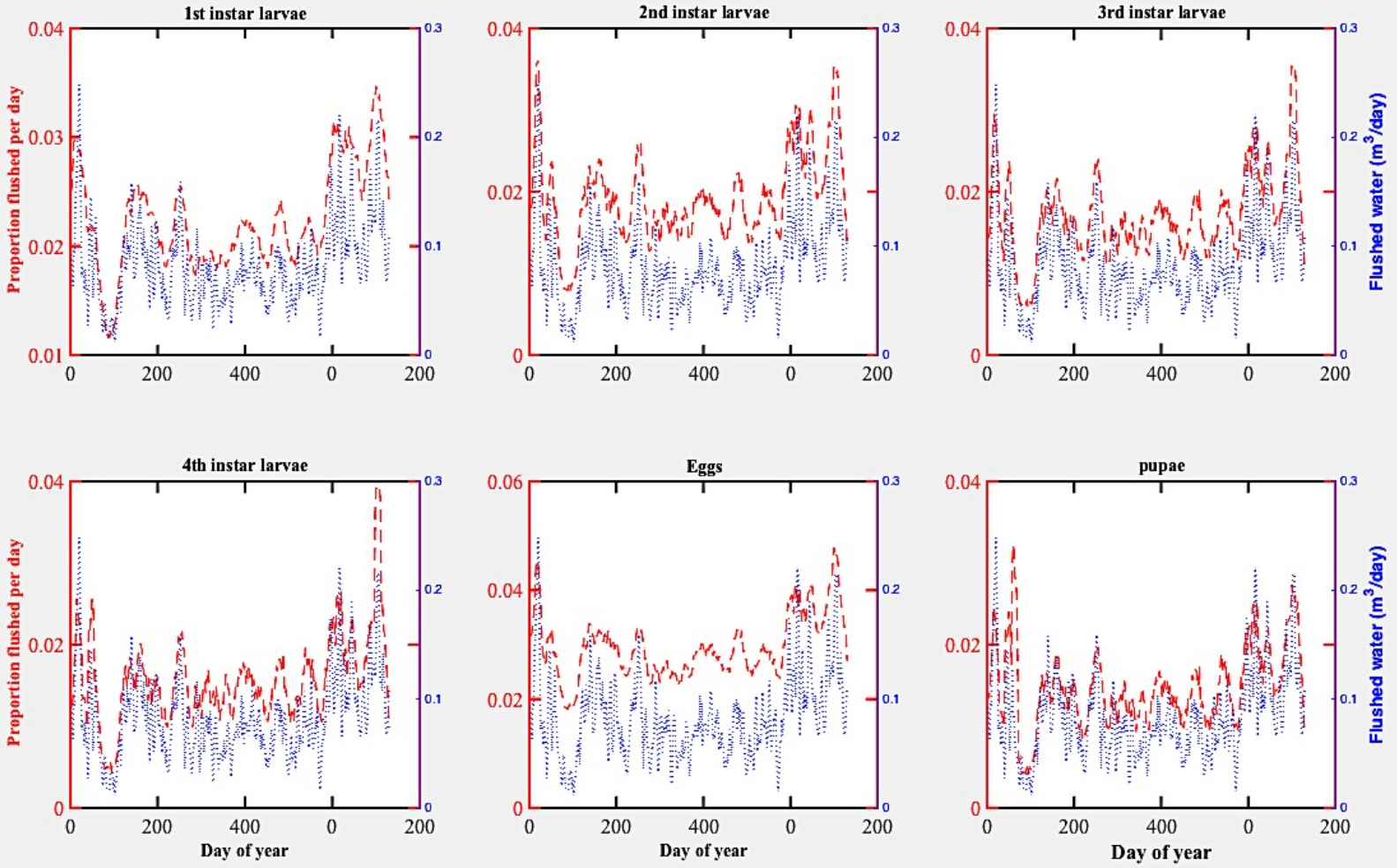
3) Dengue Transmission Model



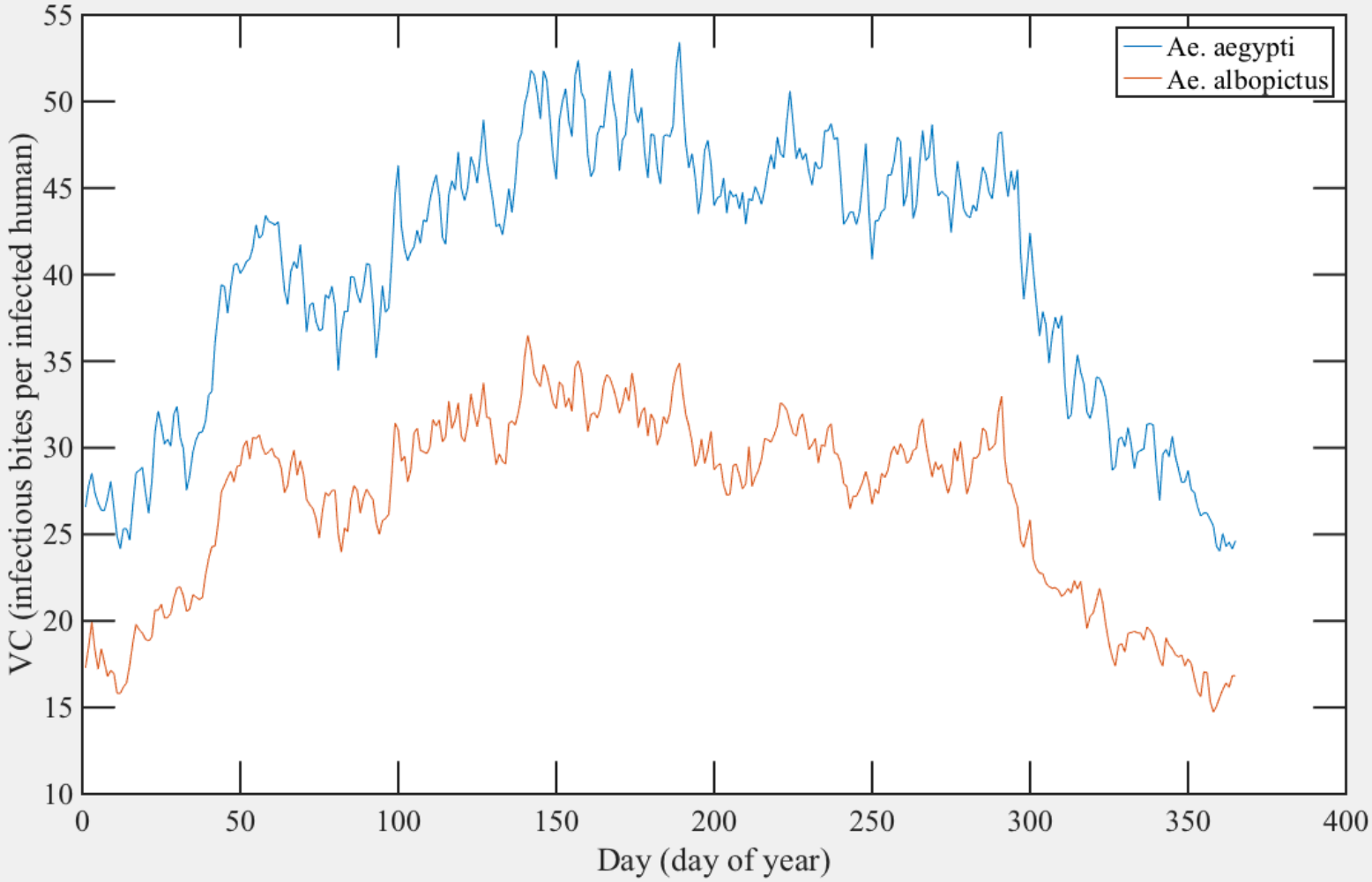
Simulations of HYDREDETS (2000-2010)



Flushing of aquatic stages



Vectorial capacity of Ae. aegypti and Ae. albopictus



Summary

- HYDREDETS model couples hydrology, entomology and disease transmission of dengue.

- The model is capable to simulate dengue under the coexistence of the two vectors of dengue , and under urban settings in endemic areas.

- HYDREDETS can be useful to assess vector control policies and study impact of climate change on dengue transmission

- A further evaluation for the model performance is needed.

Thank you